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MALATHION SPRAYS FOR CONTROLLING THE BLACK PINE LEAF SCALE ON THE SAN BERNARDINO NATIONAL FOREST

The Insect

Distribution and importance in California.--The black pine leaf scale, Nuculaspis californica (Coleman) is a native pest of ponderosa and Jeffrey pine in California. It is widely distributed throughout the range of its hosts, but causes serious damage only in limited areas. The scale has been particularly abundant for more than 20 years in the Crestline area of the San Bernardino National Forest. The infestation has resulted in death to occasional trees and a serious reduction in the growth rate of many others in recreational areas located in the Forest (fig. 1.) The U. S. Forest Service, the California State Division of Forestry, and local property owners have expressed concern about this damage and have requested information on practical control measures.

Description and habits.--The black pine leaf scale is one of the armored scales. Apparently it has but one generation a year in the Crestline area. The adult scales reach full maturity about July 1, at which time they are covered with a plastic-like black shell that is elongate in shape and about one-sixteenth inch in diameter (fig. 2). The covering of the mature male scale is slightly larger than that of the female and more elongate in shape. When fully mature, the male scale emerges from its armor covering and moves freely about. The male is equipped with a pair of delicate wings and is capable of flight. The mature female remains under the armor covering and produces eggs. The eggs hatch into tiny nymphs or "crawlers", which disperse and attack other needles. The crawlers infest the newly developed needles primarily, although occasionally they attack the older needles. The young scales are very selective in their location, always settling on the adaxial surface of the needle. When they have found a suitable spot on a needle, the crawlers insert their mouth parts and begin to feed. The first molt takes place shortly thereafter, as a result of which the insects lose their legs and antennae and become stationary. The second molt results in the initiation of the armor formation, which continues to increase in size as the insects mature. In the early stages of development the scale covering is lemon-yellow, but by the late fall the covering is nearly all black except for a small, lighter-colored cap on top.

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Figure 1.--Black pine leaf scale damage to young ponderosa pine near a dwelling in Crestline Village, San Bernardino National Forest. Trees in the center and left foreground heavily infested; trees in left background lightly infested.

Figure 2.--The black pine leaf scale on ponderosa pine near Crestline, California. (x5)

Previous Control Studies

A limited amount of work has been done by others to develop methods to control the black pine leaf scale in California. During the 1941 field season, H. L. McKenzie[1/] carried on some preliminary spray tests for the control of the scale near Hat Creek, Shasta County. McKenzie tested several materials at that time and found from these tests that a highly refined petroleum oil plus a toxicant of 4.2 percent of derris extractives dissolved in cardolite gave very promising control. The following summer, McKenzie and R. C. Hall[2/] conducted a pilot test with this material in the Crestline area on the San Bernardino National Forest and found that light oil alone gave very satisfactory control and that the addition of the toxic material gave no better results.

In 1953, E. T. Gammon of the California State Bureau of Entomology carried on a small-scale test against the black pine leaf scale on Jeffrey pine near Susanville, Lassen County. He used malathion at the rate of 1-1/2 pounds of malathion emulsion plus 1 gallon of light medium oil in 100 gallons of water, for the purpose. The spray was applied to the point of runoff, using a hand-operated pump. Gammon concluded that he obtained over 90 percent control in his tests. In 1953, and again in 1954, G. L. Downing of the Forest Insect Research Division used the same formula on an experimental basis in Grade Valley, Ventury County, on the Los Padres National Forest. His results were inconclusive because of the very low population of scale on the check trees the year after spraying.

Control Tests in 1955

During 1955, plans were developed for further tests of the effectiveness of malathion sprays to control the black pine leaf scale. The tests were staged in the Crestline area in mid-summer and were conducted in cooperation with the Arrowhead District, San Bernardino National Forest.

Method of treatment.--Malathion was selected as the chemical to be tested, on the basis of recommendations made by McKenzie and Gammon. In the water emulsion tests, malathion was used in concentrations of 1-1/2 pounds and 3 pounds per 100 gallons of water, respectively, to which was added, in each case, 1 gallon of light medium oil. The oil solution consisted of a 10 percent concentrate in diesel oil. The emulsion sprays were applied to the foliage to the point of runoff with a Bean high-pressure fire pumper. The oil solution was applied with a hand sprayer in the form of a mist, at the rate of about 2 gallons per acre. Dyed, chemically treated cards were used in the latter case to determine the rate of application.

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2/ Results of a Spray Treatment for the Control of the Black Pine Leaf Scale Infesting Ponderosa Pine on the San Bernardino National Forest. Forest Insect Laboratory, B.E.P.Q., Berkeley, Calif. June 20, 1944.

The timing of the spray application was set to coincide with the end of crawler migration after the young scales had passed through their first molt. Periodic sampling of the scale population indicated that this date would fall early in August; as a result, August 5 was the target date set and the date the spray was applied.

A total of 38 trees were used for the tests. Of this number 8 were reserved as checks and 30 were treated. The 1-1/2-lb. and 3-lb. emulsion sprays were applied to 12 and 10 trees respectively. The oil solution was applied to 8 trees. Trees were tagged with circular, metal-rimmed cardboard tags. Ten of the tags were destroyed by rodents, of which 3 were checks, 2 in the 1-1/2-lb. treatment, 2 in the 3-lb. treatment, and 3 in the oil solution.

Method of sampling scale populations.--A precontrol sampling was made of mature living 1954 scale populations on the test trees, from random sampling of branches and needles just prior to egg laying, in order to establish the relative abundance of scale for the 1954 season. An attempt was made to determine the living population of the 1955 generation of scales prior to treatment, but difficulties were encountered at this point because some of the scales were still in the mobile stage. In addition, of the total number that had settled there were a large number of questionable cases in which it could not be determined whether the scales were living or dead. It was quite apparent that natural mortality in the crawler stage was quite high.

A post-treatment sampling was made about one month after the treatments, at which time the scales were presumed to have passed through at least two molts and were only about one-quarter grown. Their covering was still lemon-yellow, but there was still some uncertainty in determining those that were alive and those that were dead. For this reason the final appraisal of results was delayed until the February 1 collection was made. The scales that had made successful attacks were then about half grown, and were all at the stage when they were covered with their black armor. At this stage it was a simple matter to differentiate between living and dead scales on the check trees. Scale bodies, firm and full of body juices, were presumed to be living. Those shriveled and dessicated were presumed to be dead. An estimate of the population on the treated trees was still difficult to determine, since practically none of the scales reached the black armor stage. It was therefore necessary to count the remnants of their bodies still remaining on the needle. This procedure introduces one element of error on the conservative side for the treated trees, since any scale bodies which fell off would not be counted. This error may account for the apparently lighter population on the treated trees in comparison with that on the checks.

In arriving at the results, Abbott's formula was used, which compensates for natural mortality that would be expected to occur on the sprayed trees if they had not been treated. The total number of scales (living and dead) was taken as the precontrol population, while the number living was taken as the postcontrol population. Mortality of scales on the treated trees due solely to the insecticide was thus determined. A random sample of ten needles each was examined for live and dead scales on each tree in the test.

Results of the Test

The population of mature living scales was estimated at 15 scales per needle for the 1954 generation just prior to egg laying, and at 27 half-grown, living scales per needle for 1955, as of February 1, 1956. The check trees had an average population of a total of 32.3 scales per needle, with 5.1 or 15.8 percent dead. The trees treated with 1-1/2 pounds of malathion per 100 gallons of water had an average of 24.5 scales per needle with 100 percent of the scales dead. The trees treated with 3 pounds of malathion per 100 gallons of water had an average of 19.8 scales per needle, with 100 percent dead. Apparently high mortality occurred among the crawlers as a result of the spraying, for not a single black-bodied scale was found in the samples from the 1-1/2 and 3-pound treatments. Those treated with the mist 10 percent concentrate had an average of 14.5 scales per needle, with 78.6 percent dead. (Table 1).

Discussion

These tests indicate that effective control of the black pine leaf scale can be obtained through an application of malathion at the rate of 1-1/2 pounds in 100 gallons of water plus 1 gallon of a light summer oil, applied with a high-pressure sprayer to the point of runoff. Not a single living scale was found on any of the samples from the trees treated with this formula. Such treatments would be limited to areas adjacent to roads or around resorts where access with ground equipment is possible. It could not be used to treat large inaccessible forest areas. Mist application of malathion in a 10 percent concentrate with diesel oil was only partly effective and cannot be recommended without further study.

One treatment is likely to be effective for several years because of the sedentary habits of the black pine leaf scale. The female scales do not move after maturity, and the only chance of reinfestation would probably be through the young "crawlers" being carried on the legs of birds and squirrels. It seems unlikely that these fragile young would, by themselves, migrate from tree to tree except in case of interlocking branches. Population records will be maintained on the treated and check trees for a period of several years to determine the effective periods of control.

At the present time we have little information on the distribution and intensity of damage by the black pine leaf scale in the Crestline-Arrowhead area. Recent observations by R. C. Hall and J. W. Kimmey of the California Forest and Range Experiment Station have indicated that there are two sources of needle damage in this area: one is a yellowing of the pine foliage caused by the feeding of the scales, and the other is the browning of the foliage, caused presumably by some physiological factor believed to be a soil moisture deficiency. Until just recently all of the browning of foliage was attributed to scale damage.

Table 1.--Counts of living and dead scales on treated and untreated trees, Feb. 1, 1956, based on a random sample of 10 needles per tree

Tree No.	Treatment	Number living scales per needle 1/	Number dead scales per needle	Total No. scales per needle 2/	Percent dead	Percent control Abbott's formulae
16	Check	19.4	3.5	22.9	15.3	
20	"	16.2	3.2	19.4	16.5	
21	"	32.0	7.0	39.0	17.9	
22	"	41.1	7.4	48.5	15.3	
23	"	27.5	4.3	31.8	13.5	
Average		27.2	5.1	32.3	15.8	
1	1-1/2 lbs./100 gal.	0	25.0	25.0	100.0	
2	"	0	25.1	25.1	100.0	
3	"	0	16.5	16.5	100.0	
4	"	0	24.2	24.2	100.0	
5	"	0	40.4	40.4	100.0	
6	"	0	29.2	29.2	100.0	
7	"	0	18.4	18.4	100.0	
8	"	0	20.8	20.8	100.0	
9	"	0	26.7	26.7	100.0	
10	"	0	18.3	18.3	100.0	
Average		0	24.5	24.5	100.0	95.2
28	3 lbs./100 gal.	0	13.1	13.1	100.0	
29	"	0	19.2	19.2	100.0	
30	"	0	22.2	22.2	100.0	
31	"	0	29.0	29.0	100.0	
32	"	0	18.0	18.0	100.0	
33	"	0	26.2	26.2	100.0	
34	"	0	32.0	32.0	100.0	
35	"	0	38.0	38.0	100.0	
Average		0	19.8	19.8	100.0	94.0
18	10% concentrate	11.3	4.7	16.0	29.4	
19	"	0.1	12.8	12.9	99.2	
36	"	0.2	18.5	18.7	98.9	
37	"	1.0	12.7	13.7	92.7	
38	"	3.1	8.5	11.6	73.3	
Average		3.1	11.4	14.5	78.6	74.7

1/ Considered as postcontrol population.

2/ Considered as precontrol population.

There is a need for an appraisal survey to determine the relative abundance of the scale in the Arrowhead-Crestline area, and for research to determine specific factors, other than scales, that may be the cause of the poor condition of the trees.

Berkeley, California
March 27, 1956

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Entomologist